A Study on Morphological Similarity between the Genera *Nanorana* and *Altirana* (Amphibia, Anura, Ranidae)

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Abstract. -Through Wilk's stepwise discriminant analysis, 16 of 18 indices of *Nanorana ventripunctata, N. pleskei*, and *Altirana parkeri* were selected and used in a numerical taxonomy study with their weights given as the following formula: W=Cx1/U. The result of clustering analysis of the Euclidean Distances between the three species reveals that *N. ventripunctata* is more similar to *A. parkeri* than to *N. pleskei* in morphology.

Key words: Amphibia, Anura, Ranidae, *Nanorana, Altirana*, China, Transhimalaya Mountains, stepwise discriminant analysis, numerical taxonomy.

TABLE 1. Number, locality, and altitude of species used.

Species	Groups	Number		Altitude
N. ventripunctata	1	10 M, 10 F	Zhongdian, Yunnan	3350 m
N. pleskei	2	10 M, 10 F	Kangding, Sichuan	3260 m
A. parkeri	3	10 M, 10 F	Bashu, Xizang	4100 m

Introduction

Nanorana ventripunctata, N. pleskei, and *Altirana parkeri* are three species of frogs in two genera that are distributed in the Transhimalaya Mountains of China. Except for morphological identification and chromosome research, we know of no other studies on these frogs that has been published.

Nanorana and *Altirana* have a close relationship (Su et al, 1985: Hu et al, 1986), and some distinguishing characters between them are vague since the discovery of *N. ventripunctata* (Fei and Huang, 1985). It is necessary to reexamine the two genera. In this paper, based on 18 external morphological indices, the authors use stepwise discriminant analysis and numerical taxonomy to compare the three species.

Materials and Methods

The number, locality, and altitude of the specimens used are shown in Table 1.

Nineteen external morphological characters were measured from each specimen, and changed to eighteen ratios, i.e. 18 indices: HEL (head length)/SVL (snout vent length), HEW (head width)/SVL, SNL (snout length)/HEW, BND (distance between noses)/HEL, BED (distances between eyes)/HEL, ELW (eyelid width)/HEL, EYD (eye diameter)/HEL, FED (distance between front angles of eyes)/HEL, AHL (hand and front arm length)/SVL, ARW (front arm width)/HEL, HAL (hand length)/SVL, SVL/LFL (leg length, TIL (tibia length)/HEL, TIW (tibia width)/HEL, TFL (tarsalia and foot length)/TSVL, FOL (foot length)/SVL, NSL (length from nose to the top of snout)/HEL, and SPN (snout process length)/HEL.

Results

After stepwise discriminant analysis, sixteen of the 18 indices were selected, their Wilk's statistic measure U (from the first step of the stepwise discriminant analysis) are shown in Table 2.

The weights of the 16 indices are given by the following formula:

$$\frac{W=Cx1}{U}$$

TABLE 2. Selected indices and their U after discriminant analysis.

Indices	TIL/SVL	FED/HEL	HAL/SVL	HEL/SVL	HEW/SVL	SPN/HEL	NSL/HEL	ELW/HEL
U	0.1903	0.2766	0.4200	0.7509	0.7937	0.5534	0.8152	0.6283
Indices	ARW/HEL	SVL/LEL	TFL/SVL	BED/HEL	EYD/HEL	AHL/SVL	FOL/SVL	SNL/HEL
U	0.8488	0.2948	0.5800	0.3349	0.9677	0.5032	0.7438	0.9453

TABLE 3. The weights of the 16 indices.

Indices	TIL/SVL	FED/HEL	HAL/SVL	HEL/SVL	HEW/SVL	SPN/HEL	NSL/HEL	ELW/HEL
W	0.5254	0.3615	0.2381	0.1332	0.1260	0.1807	0.1227	0.1592
Indices	ARW/HEL	SVL/LEL	TFL/SVL	BED/HEL	EYD/HEL	AHL/SVL	FOL/SVL	SNL/HEL
W	0.1178	0.3392	0.1724	0.2986	0.1033	0.1987	0.1344	0.1058

TABLE 4. The matrix of weighted measures of the 16 indices.

Indices	TIL/SVL	FED/HEL	HAL/SVL	HEL/SVL	HEW/SVL	SPN/HEL	NSL/HEL	ELW/HEL
1	0.2051	0.1666	0.0552	0.0356	0.389	0.0297	0.0370	0.0465
2	0.2155	0.1449	0.0600	0.0389	0.406	0.0209	0.0371	0.0389
3	0.2128	0.1480	0.0622	0.0367	0.417	0.0227	0.0364	0.0398
Indices	ARW/HEL	SVL/LEL	TFL/SVL	BED/HEL	EYD/HEL	AHL/SVL	FOL/SVL	SNL/HEL
1	0.0461	0.2492	0.1131	0.0637	0.0460	0.0785	0.0644	0.0556
2	0.0451	0.2396	0.1144	0.0590	0.0451	0.0821	0.0652	0.0535
3	0.0455	0.2448	0.1161	0.0683	0.0457	0.0858	0.0627	0.0548

TABLE 5. The Euclidean Distances among the three species. Unit: 10^{-3}

	Nanorana ventripunctata	*Nanorana pleskei*	*Altirana parkeri*
1	0	0.8868	0.1707
2	0.8868	0	0.8787
3	0.1707	0.8787	0

Here C is a coefficient used to regulate the size of weight, which is given according to the condition, and U is the Wilk's statistic measure. Its calculating formula is: $U = |W|/|T| = |W|/(|W| + |B|)$, where W is the variance in group, B is the variance between groups, T is the total variance. This formula reveals that the smaller the U, the more important the index. So the weighting formula used in this paper is agreeable with the weighting principles. In addition, it has some merits when compared to other weighting formulas used in the literature: 1) No negative weights appear; 2) As a measure of the importance of characters, U has been accepted commonly, and as a measure of weights, it may be accepted easily; 3) Convenient for calculation.

The calculated weights of the 16 indices are shown in Table 3.

Multiplying the measures of the 16 indices with their weights, a numerical matrix is given as shown in Table 4.

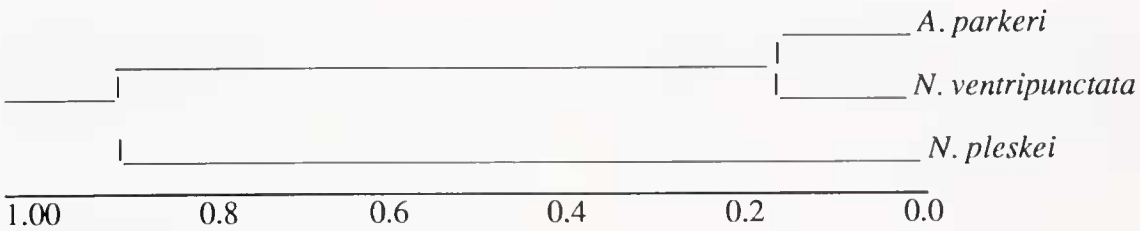

FIG. 1. The UPGMA phenogram of the three species based on Table 5.

Table 6. Some identification characters between the three species.

Nanorana pleskei	*N. ventripunctata* and *Altirana parkeri*
tympanum under skin, but visible; columella exists	tympanum and columella absent
nasals separate, not connected with frontal-parietal	nasals connected with each other and connected with frontal-parietal
precoracoid ossified incompletely	precoracoid ossified completely
clavicle short, not attach epiconicoid	clavicle long, attach epiconicoid
the first low labial teeth of tadpole shorter than the second obviously	the first low labial teeth of tadpole slightly shorter than the second

The Euclidean Distance is selected in this paper to measure the morphological differences between the three frogs. The formula is: $D_{ij}= \sqrt{\Sigma(X_{ik}-X_{jk})^2}$. The calculated Euclidean distances among the three frogs are shown in Table 5.

Figure 1 detects that the distance between *N. ventripunctata* and *A. parkeri* is the shortest. The two frogs meet together at the distance 0.1703, then they meet with *N. pleskei* at the distance of 0.8827. The morphological similarity of *N. ventripunctata* and *A parkeri* is closer than that of *N. ventripunctata* and *N. pleskei*.

Discussion

Up to the present, the differences between the genera *Nanorana* and *Altirana* reported on by Tian and Jiang (1986) contained the most details. But the genus *Nanorana* as they meant, did not contain *N. ventripunctata*, so it was just the differences between *N. pleskei* and *A. parkeri* that they noted.

The characters of *N. ventripunctata* show that this species is more similar to the genus *Altirana* than to the genus *Nanorana* as shown in Table 6. The numerical taxonomy research of this paper and the biochemical systematic study (Lu and Yang, 1994) show the same results. It seems logical to take *ventripunctata* out of genus *Nanorana* and place it in genus *Altirana*, but the biochemical systematic study reveals that the Nei's (1972) genetic distances between the three frogs are 0.30, 0.57, 0.57, respectively, smaller than 1.05 obviously, but larger than 0.15. We feel that these differences are at the species level, not the generic level (Thorpe, 1983). Thinking of the principle: in order to avoid more monogenera, the interruption of a genus with other genera should be anti-relative

with the size of the genus, i.e. the number of species contained in this genus, the authors suggest that the genus *Altirana* be cancelled and the species *parkeri* be placed in the genus *Nanorana*..

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